THE EXPLOSIVES ENGINEER

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Forerunner of Progress in Mining, Quarrying, Construction

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Views and opinions expressed by the authors of articles in this publication are their own, and they do not necessarily represent those of the publisher.

The Beavers, a newly organized group of heavy-construction men, held its first annual awards dinner-ceremony in the Hotel Statler at Los Angeles on January 27. The highlight of the ceremony was the presentation of awards to 16 men who had distinguished themselves to an exceptional degree in the field of heavy-engineered construction projects west of the Mississippi.

Photographs of the award recipients and a brief account of the ceremony are presented on pages 6 and 7.

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The diversified activities of The Eagle-Picher Company stem from a consolidation of interests of The Eagle White Lead Company and Picher Lead Company in 1916. Following the merger, operations were started under the name of The Eagle-Picher Company and new mines were opened and zinc smelters acquired. Today, in addition to operating mines in the Tri-State District (Missouri, Kansas, and Oklahoma), in the states of Arizona and Nevada, in the Illinois-Wisconsin area, and in Mexico, Eagle-Picher geologists are continuously prospecting for new mineral deposits.

The first discovery of zinc ore was made near Commerce, Oklahoma, in 1906. Eight years later, Eagle-Picher crews made their first strike in the locality, on the allotment of Harry Crawfish, a full-blooded Quapaw Indian. News of the strike brought a rush of lease negotiators, promoters, churn-drill contractors, and operators to the Quapaw Reservation in Oklahoma. Many small mills were built and their indiscriminate operations proved wasteful of natural resources. Eagle-Picher devised a plan for the construction of a large central mill to provide positive weighing, sampling, and control of lot shipments. The success of the plan made possible the almost complete depletion of the remaining low-grade ore.

In shaft-sinking operations, Eagle-Picher uses a round made up of 14 to 16 drill holes, each 5 ft. deep. For mining underground, the company uses the room-and-pillar method, with blast holes drilled from air-powered crawler-mounted jumbos. The overall consumption of explosives ranges from 0.44 lb. a ton in high-roof mines to 1.13 lb. a ton in mines with low headings.

A description of the diversified activities of The Eagle-Picher Company begins on page 8.

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In the spring of 1954, news services gave world-wide publicity to the discovery of a crack in Contractor's Hill at the Panama Canal. According to the reports, the crack was of such proportions that a rock slide on the hill, in the Gaillard Cut, was imminent. If this happened, the probabilities were that the Canal would be closed to maritime traffic for a year.

The Panama Canal Company, operators of the famous international waterway, decided to remove part of Contractor's Hill and a contract to do the work was awarded to Tecon Corporation of Dallas, Texas.

The contract was completed after 15 months of intensive activities. Operating details included the blasting and disposing of 2,460,000 cu. yd. of volcanic agglomerate rock and 670,250 cu. yd. of shale. Please turn to page 16.

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Officials of Pickands Mather & Co. were hosts at ceremonies in Hibbing and Ely, Minnesota, on August 26 and 28 respectively, to honor the employes of its Mahoning and Zenith mines for having won top honors in the 1954 National Safety Competition.

A summary of the proceedings is presented on page 23.

EDITORIAL STAFF: JOSEPH I. HORTY, *Editor;* GERTRUDE A. DONNELLY, *Assistant Editor;* ELIZABETH M. JOYCE, *Associate Editor;* EDWARD L. GRANT, *Art Editor;* FRANK J. CANOVA, *Production Manager;* CHARLES E. RABENOLD, *Advertising Manager;* MONTGOMERY R. BUDD, *Director.*

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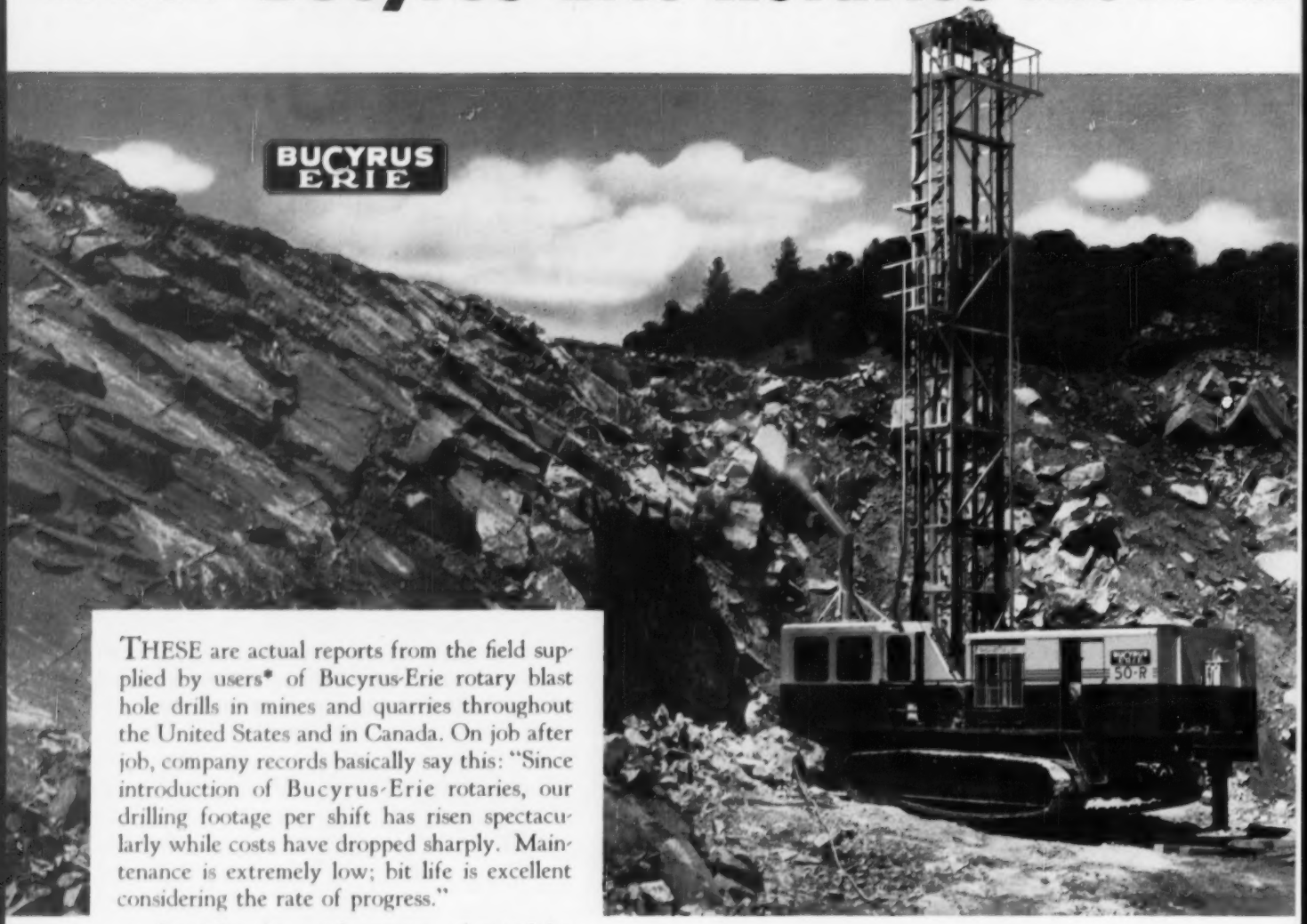
BPA

Drilling Costs Go Down When Bucyrus-Erie Rotaries Move in



THESE are actual reports from the field supplied by users* of Bucyrus-Erie rotary blast hole drills in mines and quarries throughout the United States and in Canada. On job after job, company records basically say this: "Since introduction of Bucyrus-Erie rotaries, our drilling footage per shift has risen spectacularly while costs have dropped sharply. Maintenance is extremely low; bit life is excellent considering the rate of progress."

Consider the performance obtained by these owners in the light of your own drilling requirements. Then let us give you the complete story on Bucyrus-Erie rotary drills — the 50-R, with electric power, for drilling 9⅞ to 12¼-in. holes; the 40-R, with diesel-electric or full electric power, for drilling 6¾ to 9-in. holes.

** Names will be supplied on request.*

In an Indiana Coal Mine a Bucyrus-Erie rotary drilled a total of 1,325 feet in a single 6¾ hour shift. Overburden consisted of a medium-hard sandstone with overlay of hard shale. This record was achieved with 10⅞-in. holes averaging 40 feet in depth. Thirty-three holes were drilled in one day's work; average footage drilled was 196 feet per hour.

At a Canadian Iron Ore Property progress of 60 feet per hour, drilling both 9-in. and 9⅞-in. holes in hard iron ore; was reported.

In a Pennsylvania Anthracite Strip Mine the material was conglomerate, granite, and sandstone, very hard and abrasive, and badly broken up and fissured. A 50-R drilled 9⅞-in. hole at the rate of 24 feet per hour. During 256 hours working time, the rotary put down 6,125 feet.

A Cement Company in California, drilling in hard limestone formations, reported a drilling cost of 76 cents per foot of 9⅞-in. hole with their Bucyrus-Erie rotary as compared to $2.52 per foot of 9-in. hole with other drills.

Another Pennsylvania Hard Coal Stripping Operation recorded 27,750 feet of 12¼-in. hole drilled during a total of 1,458 hours working time. Material was hard and medium sandstone, shale, conglomerate, and slate. Footage per hour was 19 feet, with holes averaging 70 feet in depth. Average bit life was 1,762 feet.

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Carl Ernest Reistle, Jr.

PRESIDENT, AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS

A Biography

With the induction of Carl Ernest Reistle, Jr., as president of the American Institute of Mining and Metallurgical Engineers on February 23, that high office will be administered, during 1956, by an outstanding leader in the petroleum industry, a successful author, and a many-times inventor. As a vice president and member of the board of directors of Humble Oil & Refining Company, Mr. Reistle is in charge of the company's Production Department.

Carl, as his friends and associates know him, was born in Denver, Colorado, June 26, 1901, the son of Carl Ernest and Leonora Isabel (McMaster) Reistle. He received his grade-school education in Denver and completed the high-school courses in Oklahoma City, Oklahoma. In 1922, he was graduated from the University of Oklahoma with a bachelor of science degree in chemical engineering. During his undergraduate days at the university, he was a member of Alpha Chi Sigma, Sigma Tau, Tau Beta Pi, engineering fraternities; Pi Epsilon Tau, honorary petroleum engineering fraternity; and Sigma Xi, honorary science fraternity. He was also elected to membership on St. Pat's Board, Engineering College.

Carl became identified with the petroleum industry during his college years, working as a roustabout for Carter Oil Company during summer vacations. Upon graduation from the university, he accepted a position with the U. S. Bureau of Mines in Bartlesville, Oklahoma, as a junior petroleum chemist. He remained with the Bureau for eleven years, working in various capacities. During this period, he visited and worked in many of the largest oil fields in the United States and was the author of a number of articles on the subjects of oil field brines, paraffin problems in the production of crude oil, and the operation of flowing wells.

In 1933, Carl accepted the chairmanship of the East Texas Engineering Association, a cooperative organization formed to obtain engineering facts on the efficient operation of the East Texas Field. His efforts contributed very definitely to the establishment of efficient production rates and improved practices in the field.

Carl Reistle began his long association with Humble Oil & Refining Company in August, 1936, when he was appointed engineer in charge of the Petroleum Engineering Division. Four years later, he was promoted to chief petroleum engineer. In 1945, he was given two promotions: general superintendent of the Production Department in February, and manager of Production Operations in August. He was elected to the board of directors of Humble Oil & Refining Company in 1948, and, in 1955, he was made a vice president.

During World War II, Carl was appointed technical advisor for District III of the Petroleum Administration for War. He was also national vice chairman of the Oil Industry Advisory Committee for the Office of Price Administration.

Soon after Mr. Reistle took his first job, he began the writing of technical articles pertaining to the oil industry. From 1925 to date, he has been the author or coauthor of sixteen technical papers. He holds seven patents on improvements within the industry.

In addition to being the 1956 president of the American Institute of Mining and Metallurgical Engineers, he is a member of the American Petroleum Institute, and the Mid-Continent Oil & Gas Association. Active in the Junior Achievement movement, he is a member of its National Board of Directors and president of the Houston Chapter.

Carl E. Reistle, Jr., married Mattie Anne Muldrow on June 23, 1922, in Bartlesville, Oklahoma. They have four children: Mrs. George F. Pierce, Jr.; Mrs. James T. Clark; Mrs. W. Hayes Holliday; and Carl Ernest Reistle III; and six grandchildren. The family home is at 3196 Chevy Chase, Houston, Texas.

His club affiliations include the River Oaks Country Club and the Houston Club.

Although Carl's record of achievement indicates that he is an extremely busy man, he finds time to relax and enjoy all sorts of out-of-doors activities, with special emphasis on duck hunting in Texas, fly fishing for trout in the Rockies, and snook fishing in Florida.

CARL ERNEST REISTLE, JR.

Honored By The Beavers

GUY F. ATKINSON

HARRY W. MORRISON

HENRY J. KAISER

HERMAN BROWN

C. W. WOOD

C. B. WILLIAMS

M. HARVEY SLOCUM

LEE T. GRIDER

JULIAN HINDS

BERNHARD F. JAKOBSEN

MAJOR-GEN. THOMAS M. ROBINS
(U.S.A. Ret.)

J. S. FOSTER

DR. NATHAN A. BOWERS

WILLIAM R. ELLIS

JOHN P. SHIRLEY, SR.

GUY L. STEVICK

THE BEAVERS' FIRST ANNUAL AWARDS CEREMONY

Newly organized group of contractors pay tribute to sixteen men for outstanding contributions to progress in heavy-engineering construction west of the Mississippi

Approximately 1,000 members and guests of the Beavers, a newly organized group of heavy-construction men, met at Hotel Statler in Los Angeles, California, on January 27 to participate in the first annual awards dinner-ceremony of the organization. William A. Johnson, chairman of the board of American Pipe & Construction Company of Los Angeles, president of the group, presided at the ceremony.

One of the objectives of the Beavers is to pay tribute annually to those men who, by their demonstrated skill, responsibility, and integrity, have distinguished themselves to an exceptional degree in the profession of heavy-engineering construction west of the Mississippi.

The first annual awards of the Beavers were made to sixteen men for outstanding accomplishments in their respective fields. The men chosen to receive the awards were:

MANAGEMENT: Guy F. Atkinson, chairman of the board, Guy F. Atkinson Company, South San Francisco, California; Harry W. Morrison, chairman of the board, Morrison-Knudsen Company, Boise, Idaho; Henry J. Kaiser, chairman of the board, Kaiser interests, Oakland, California; and Herman Brown, president, Brown & Root, Inc., Houston, Texas.

SUPERVISION: C. W. Wood, vice president, General Construction Company, Seattle, Washington; C. B. Williams, vice president, Morrison-Knudsen Company, Boise, Idaho; M. Harvey Slocum, construction engineer (dams), Alhambra, California; and Lee T. Grider, veteran superintendent, Los Angeles, California.

ENGINEERING: Julian Hinds, consultant, Santa Paula, California; Bernhard F. Jakobsen, consultant, Menlo Park, California; and Major-General Thomas M. Robins (U.S.A. Ret.), consultant, Portland, Oregon.

SUPPLY: J. S. Foster, vice president, Lidgerwood Manufacturing Company, Orangeburg, South Carolina; and Dr. Nathan A. Bowers, consulting editor, McGraw-Hill Publishing Company, Atherton, California.

Posthumous awards were made to William R. Ellis, vice president, Hercules Powder Company, Wilmington, Delaware; John P. Shirley, Sr., vice president, Gunther & Shirley, Los Angeles, California; and Guy L. Stevick, western manager, Fidelity & Deposit Company, San Francisco, California, for their contributions to construction progress in the West until their deaths last year. The citation accompanying the award to Mr. Ellis reads:

> Remembered by scores of friends and associates as a brilliant engineer and administrator, the late William R. Ellis during his lifetime contributed in many practical ways to increase the knowledge of explosives and their usage. Outstanding was his help in the development of the jumbo method of drilling and blasting which made possible the Hoover Dam tunnels. Bill, as he was affectionately known, possessed a warm personality which won him friends and admirers in every walk of life.
>
> Mr. Ellis was born in California in 1886, graduated from Stanford University and worked in Western gold and copper mines before joining Hercules Powder Company in 1915. With Hercules, he served in a variety of sales, service, and administrative capacities on the West Coast culminating in his appointment as general manager of the Explosives Department in 1936. He was elected a vice president and a member of the executive committee in 1945. He retired in 1954 and passed away a year later in California. Surviving are three sons, William C., John R. B., and Thomas F. Ellis.
>
> In the words of those who knew him closely, Mr. Ellis is described as a two-fisted man who was respected by all who knew him for his mastery of whatever job fell his way and who in turn respected all the men who worked in his field. Bill Ellis served the construction industry well by his expert and comprehensive knowledge of his own business.

THE EAGLE-PICHER COMPANY

A review of some of the developments in mining zinc and lead in the Tri-State District

SIM S. CLARKE*

THE diversified activities of The Eagle-Picher Company in the Tri-State District (Missouri, Kansas, and Oklahoma) began with the founding of The Eagle Company in 1843. The latter company built a plant in Cincinnati, Ohio, to manufacture white lead by the old Dutch process. In the early 1870's, a firm in Joplin, Missouri, called Picher Lead Company, built a custom lead smelter. The Eagle Company and the Picher Lead Company interests were consolidated in 1916 and operations began under the name of The Eagle-Picher Lead Company.

About 1870, E. R. Moffett and J. B. Sergeant made a rich lead strike on Joplin Creek. After acquiring more leases in the area and expanding operations, Moffett and Sergeant sold their holdings to Oliver H. and William H. Picher in 1887. At that time, the Pichers were operating under the name of The Picher Lead and Zinc Company. Two years later, the company was reorganized and began doing business under the name of The Picher Lead Company. In 1912, the reorganized company bought the Galena Lead Smelter at Galena, Kansas.

On June 1, 1916, The Picher Lead Company and The Eagle White Lead Company of Cincinnati merged. The name chosen for the new organization was The Eagle-Picher Company. The new company opened mines in Oklahoma and Kansas, and, within a short

*Former General Superintendent of Mines The Eagle-Picher Company, Joplin, Missouri

THE CENTRAL MILL: This large, centrally located mill was designed and constructed by Eagle-Picher. Its positive sampling, weighing, and shipping control facilities were soon apparent. Within a short period, other operators cooperated by bringing ore from their lands for handling through this central mill. It made possible the almost complete depletion of the remaining low-grade ores.

time, it was producing more zinc concentrates than lead. Zinc smelters were acquired at Henryetta, Oklahoma, and at Hillsboro, Illinois.

Besides operating mines in the Tri-State District, in the states of Arizona and Nevada, in the Illinois-Wisconsin area, and in Mexico, Eagle-Picher has groups of geologists working continuously in various parts of the country exploring and investigating possible new mineral deposits.

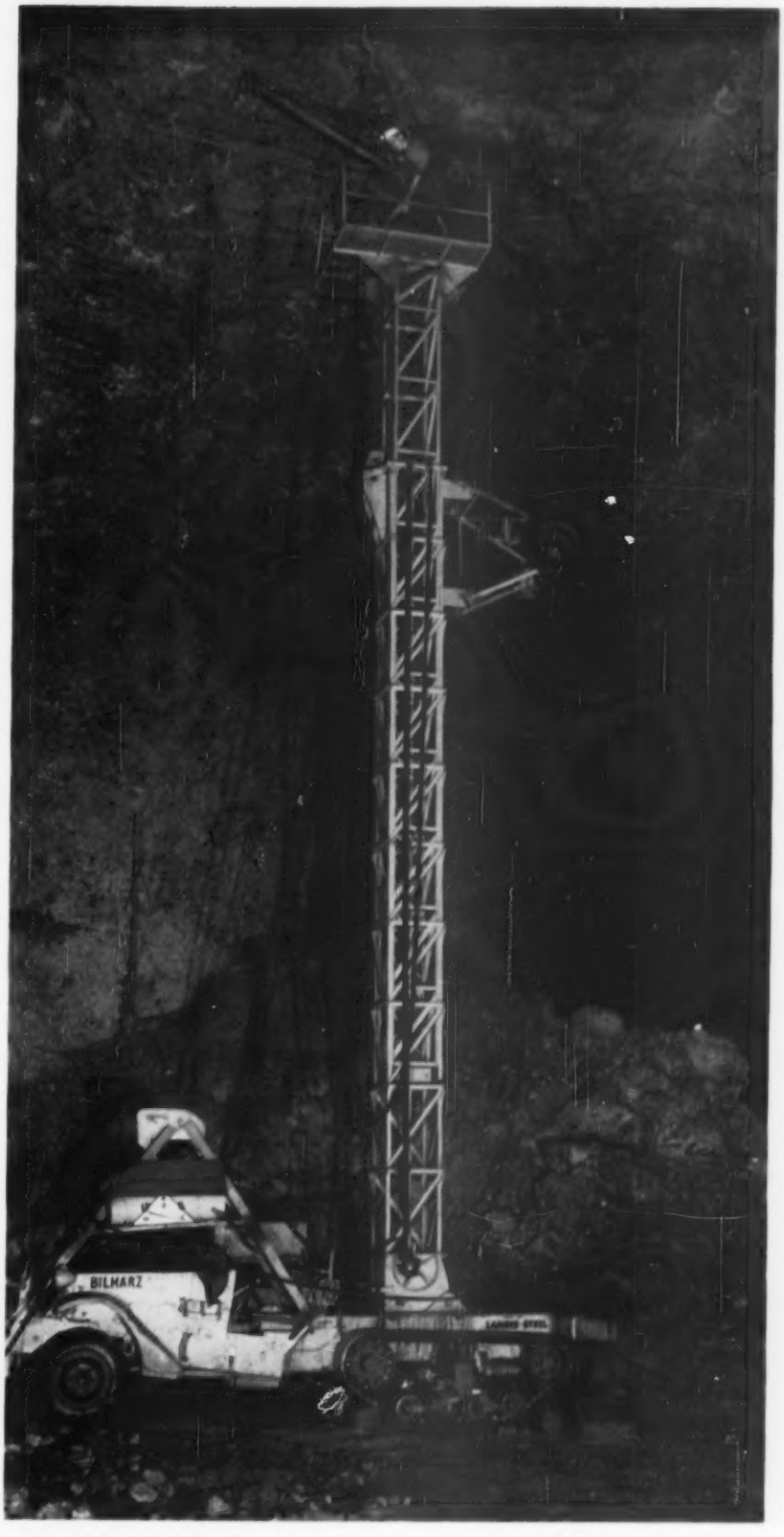
Early Developments

Zinc ore was discovered near Commerce, Oklahoma, in 1906-07, at an average depth of 100 ft. Several small mills were built on the orebodies. This gave a decided impetus to further prospecting around Commerce.

Crews of The Eagle-Picher Company had been drilling on leased ground in the southwest and west fringes of the area, which later turned out to be the main orebody. They made the first strike for the company in October, 1914, on the allotment of Harry Crawfish, a full-blooded Quapaw Indian. This strike in Oklahoma led to a stampede of lease negotiators, promoters, churn drill contractors, and operators from "The Old Country" around Joplin and Webb City.

Practically all the acreage on the Oklahoma side was on the Quapaw Indian Reservation. Each head-right allotment consisted of 200 acres, and leases had to be approved by the Indian Department of the U. S. Department of the Interior. The Government's general policy requires a mill on each 40 acres. In quite a few instances, a 40 was divided and a mill was built on each 20. This practice was wasteful of natural resources as it required mining the heart of the ore run. Also, a one-shift operation of the concentrators resulted in high tailing losses.

A drop in the price of zinc caused either a shutdown or high grading. When a mine could not produce enough ore to support a daily operation of the concentrator, the mine was abandoned or subleased to gougers. Very few of the gougers were concerned with the ultimate condition of a mine after they had slabbed, or had entirely removed the pillars. Their methods resulted in bad falls of ground and made the mine unsafe for re-entry. Shafts were neglected and



MINING IN THE ROOF: Eagle-Picher uses telescopic masts to take down mineralized roof that was passed up as too low grade ore in the early days of hand mining.

JUMBO DRILLING: Mine headings are advanced by drilling blast holes from air-powered crawler-mounted jumbos carrying drill masts reaching from 12 to 20 ft. The introduction of jumbos and better steel has resulted in a decided increase in drill-hole production.

many of them caved. It was apparent that if this practice continued many mines would be abandoned and an enormous tonnage of low-grade ore would be left in the ground.

Eagle-Picher devised a plan for the construction of a large mill, centrally located, where all the mined ore could be milled. The Government's Indian Department realized the financial benefits to the Indian owners that would result from central milling under approved and positive weighing, sampling, and control of lot shipments. This department also saw that the plan would permit almost complete depletion of the remaining low-grade ores.

Not long after the company's central mill was in operation, the prejudices and doubts as to the success of the plan were forgotten. Its fairness to the shipper was apparent and other landowners began to cooperate with the central milling of the ore from their lands.

A few years ago, the same allotments had reached the point where they could not produce sufficient tonnage to warrant the cost of maintaining a separate hoisting unit. The Indian Department was quick to see that, unless a change in operating policy were made, its Indian wards would be deprived of their income from royalties. As the grade of ore was about the same, the commingling of ores from different allotments was suggested and approved. This permitted ores to be hoisted at any shaft that was practical. All that was necessary was to keep an accurate record of the tonnage hoisted from the different allotments and to prorate the royalties. This plan will undoubtedly permit almost complete depletion of the various orebodies, and, in time, the practice will be area-wide.

Prospecting

The mineralized area lies in rolling prairie country with no outcrops showing. In the early days, large companies were rather slow to enter the field. Later, when the field was well developed, they came in and purchased operating mines.

Experiments proved that the most practical and economical way to prospect was with churn drills. Diamond drilling costs were prohibitive because of the highly abrasive nature of the

LOADING DYNAMITE CHARGES: The average primary blast consists of 14 to 16 drill holes, each 5 ft. deep, loaded with 100 to 120 cartridges of a semigelatin type of explosives. Results are consistently satisfactory.

chert. Records show that costs were sometimes as high as $4 a ft. for diamonds alone. All churn drilling was and is done by independent contractors at a fixed price. At present, it is $1.90 a ft. for 6¼-in.-diameter holes. When desired for ventilation purposes, casings are left in the holes and the company pays for them. Otherwise, when a hole is bottomed, the contractor pulls up the casing.

As the depth of a hole nears the mineralized beds, the drill cuttings are panned to determine the presence of lead or zinc sulphides. If the samples appear to be of commercial grade, the driller limits his progress to runs of 2½ ft. The cuttings are bailed out after each run and dumped into small individual holes dug in the soil. An Eagle-Picher field man or geologist checks and logs each drill hole and takes samples of interesting cuttings for assay.

The contractor usually makes his profit in drilling through the shale, which runs from 50 to 200 ft. thick. His troubles start when he hits the chert, especially if the ground contains water courses or boulders. In chert, drill bits are resharpened after drilling about 5 ft. In uniform chert, an average of 28 ft. of hole a shift is considered good progress. In the shale, 100 ft. of hole a shift is a fair average.

Shaft Sinking

Shafts are either 6 by 6 ft. or 5 by 7 ft. in the clear. The 6 by 6-ft. size is the popular one at this time. Generally, shafts are sunk by contractors at varying prices ranging from $18 to $25 through shale, and from $25 to $35 in the chert. When the water inflow exceeds 200 gals. an hour, the contractor may quit the job or negotiate a new contract. Shafts are cribbed with 2 by 6-in. solid wooden cribbing for about 20 ft., with open cribbing the remainder of the way. Sets of 6 by 6 in. are put in at frequent intervals to support the cribbing. A filling of old lumber and slabs is used for backing.

Contractors furnish all the labor and explosives required, and cut and set the cribbing. Eagle-Picher furnishes all equipment, power, and cribbing lumber.

The company has found it advantageous to concrete a 15 to 20-ft. collar because the upper 20 ft. is the part that rots first. Some tests are now in progress using treated cribbing.

Small cans that hold from 800 to 1,000 lb. are used in sinking the shaft. The hoistman pulls a can a few feet above the derrick room floor and then pulls a flat deck car under the can, which is lowered and unlatched from the hoist cable. He then trams the load out for dumping.

In sinking shafts in the early camp days, water was a problem. When it was struck, a pump seat was cut and pumps installed. Then sinking operations were resumed until the length of suction was reached and another pump seat was cut. The procedure was followed until the shaft was bottomed. Currently, water is not a problem as, in most instances, the water table is at the bottom of the shaft.

Unfortunately, in parts of the field, hydrogen sulphide was present in the water which resulted in an eye ailment called "pink eye." This affliction was painful and frequently caused blindness lasting a day or two.

Blasting

The average round for blasting in an Eagle-Picher shaft is made up of 14 to 16 drill holes, each 5 ft. deep, with a four-hole diamond cut drilled at the corners of a 2½-ft. square. The holes are angled toward the center of the cut. Either two or three holes are drilled on the sides. All square-up holes are spotted 8 in. in from the wall. Using 100 to 120 cartridges of a semigelatin type of explosives to load the drill holes, this round averages an advance of 4 ft. per shift.

DIESEL-POWERED LOADERS: Approximately 80 to 90 per cent of hoisted dirt is loaded by diesel-powered loaders. Equipment maintenance costs are high because of the abrasive nature of the rough dirt and the ragged bottoms in the mines.

In shale, many blast holes are made with an auger drill. The usual round, consisting of four holes in the cut and four holes in the corners, is loaded with about 40 cartridges of semigelatin dynamite. Results average 4½ ft. of shaft per round. Mucking is done by hand.

In most of the primary blasts, the dynamite charges are primed with blasting caps and safety fuse. As an added safety factor, these shot-primers are encased in a cardboard shell. The overall consumption of explosives ranges from 0.44 lb. per ton in high-roof mines up to 1.13 lb. per ton in mines with narrow, low headings.

Frequently, the drill holes were squibbed to enlarge them at the bottom. After squibbing, each hole was loaded with 100 to 120 cartridges of explosives. Later studies showed that the tons of ore broken per foot of hole drilled, or the pounds of explosives used per ton of ore broken, did not justify squibbing. When holes were squibbed, the explosives loading factor was about 1½ lb. per ton. Without squibbing, it is 0.77 lb. per ton.

Mining

Eagle-Picher uses the room-and-pillar method of mining, or open stope as it is sometimes called. Owing to the irregularity of the ore runs, other methods have been tried but the operators have always returned to the room-and-pillar method.

Before mine mechanization, headings were advanced by drilling from a drill post with a 4-ft. arm. Then the stope, or bench, was mined in either one or two benches, depending upon the thickness. This was done with drills mounted on tripods. If the bench exceeded 14 ft. in thickness, a row of horizontal relief holes, called splitters, was drilled, sometimes to a depth of 15 ft. When mucked out, the remaining bed was drilled out with stope holes, or lifters.

Now, drilling is done from air-powered crawler-mounted jumbos carrying one-piece drill masts reaching from 12 to 20 ft. In higher ground, two-piece telescopic masts are used. One model extends to 35 ft.; the latest model extends to 70 ft. The 70-ft. masts are used to take down mineralized roof that was passed up in the days of hand mining as too low grade.

Slab rounds are drilled from top to bottom. In sheet ground 10 to 12 ft. thick, three drills can be mounted on a mast. In higher ground, the general practice is to drill and blast a slab undercut round. After a blast is fired, the jumbo climbs the muck pile to drill the upper part of the heading.

Nearly all of the drifters are 3½ in. A few 4-in. drills are used in sheet ground. Air pressures vary from 80 to 90 lb. at the machine. Some jacklegs are in use, particularly in long-hole prospect drilling. They are proving very satisfactory for that work.

The use of higher grade drill steel and carbide bits has reduced costs. The consumption of drill steel per ton

of rock has dropped from 0.10 lb. per rock-ton to 0.065 lb. per rock-ton. Despite these improvements, bit and steel costs are still among the large items of expense that must be reduced even further. The country rock chert is highly abrasive and greater improvements in steel and bits are a challenge to the manufacturers.

The employment of jumbos and better steel has resulted in a decided increase in drill production. Their use has also contributed to reduced downtime in the breakage cycle. A few years ago, 45 to 50 tons broken per drill shift was considered good. At present, the company averages 100 tons broken per drill shift. At one heading, the results exceed 200 tons per drill shift.

Compressed air is supplied from two central electric-powered air plants which are tied in with a pipeline loop serving the centrally located mines. A few isolated mines have their own air plant of either one or two compressors. All drill steel is made up and serviced in a modern steel shop. Deliveries of steel and pickups of damaged or broken steel are made each day.

Mechanization has prolonged the life of the Tri-State field by several million rock-tons of such low grade that it would have been impossible to have mined it economically with the hand methods of the past.

Last year, the combined recovery of zinc and lead was 3.69 per cent, with an average of 17 tons per man-shift. Some of the more efficient mines reached 22 tons per man-shift. Twelve years ago, the tons produced per man underground were a little more than 5 tons a shift. Mechanization was then in its infancy.

Loading

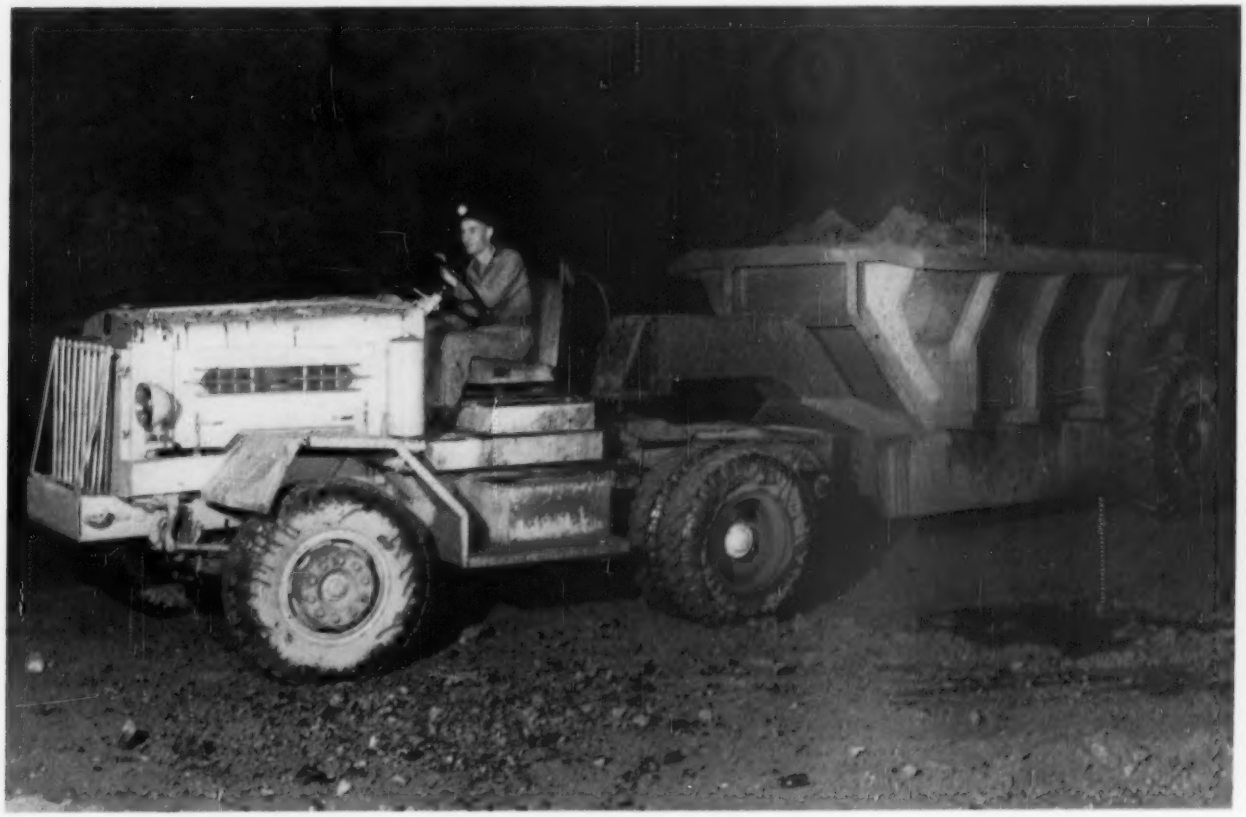
Approximately 80 to 90 per cent of hoisted dirt is loaded by diesel-powered loaders. Several different models and makes are in use: Allis-Chalmers HD-5 and HD-9; Eimco Types 104 and 105; Caterpillar D4 and D6; and a Thew-Lorain. Because of the abrasive nature of the rough dirt and the ragged bottom, maintenance costs are higher than in limestone.

The remainder of the tonnage hoisted is loaded by three-drum slushers mounted on a crawler chassis, either electric- or air-powered. Slusher loaders do not have the capacity and maneuverability of diesel loaders but they have a definite place in conditions favorable to their use. From 200 to 600 tons can be loaded with diesel loaders per shift, varying with the size of the dirt pile on which the loader is working. Slushers will load from 150 to 250 tons per shift.

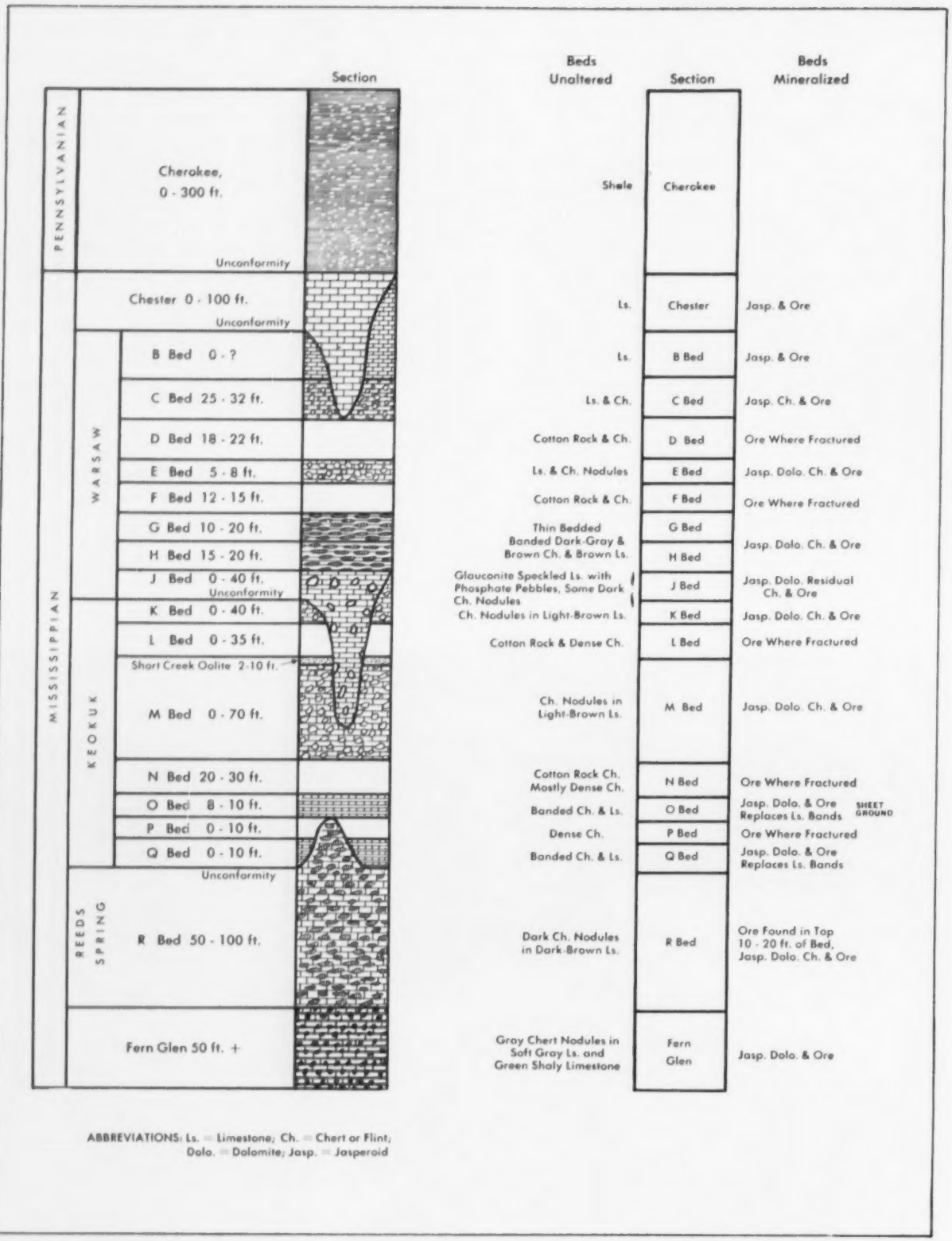
Building roads for truck haulage is exceptionally hard on equipment, especially for track-rail assemblies. To reduce the wear as much as possible, bucket lips and crawler pads are half-soled with armor plate alloy that is fairly wear resistant.

Haulage

The progressive steps in haulage are interesting. First, there was mule



HAULAGE: Hauling blasted ore underground in an 18-ton semitrailer. The installation of battery trucks proved trackless mining to be the answer to lower costs and greater flexibility in Eagle-Picher mines.



GEOLOGIC SECTION: This tracing of a geologic section of the mineralized beds was made by Eagle-Picher in May, 1949.

T. SPENCER SHORE: Under the direction of T. Spencer Shore, president of The Eagle-Picher Company, activities are being expanded and diversified.

haulage; then tail-rope haulage was introduced in certain mines. Next, three- and four-drum haulage hoists were built, which provided a wide range in any direction. This was followed by the installation of battery trucks, which proved that trackless mining was the answer to lower costs and greater flexibility. Several diesel-powered types of truck bodies are in use. Where there is turn-around room, the semitrailer is found to be easier on tires and on springs than the dump bed. Capacities are 10 tons on the dump bed and 10, 15, and 18 tons, respectively, on the three sizes of semi-trailers.

For economy in tires and frames, road maintenance is a must. The mines are equipped with diesel-powered road graders. Mill tailings are dumped down convenient drill holes or into unused shafts for road surfacing.

Hoisting

Hoisting methods as practiced in this field are quite unique and are a source of much favorable comment by visitors from other mining camps: In small-tonnage mines, two men constitute a crew — a hoistman and a hooker. In large-tonnage mines (dirt hauls), a hopper puller is added.

The hoist is set 6 or 8 ft. above the top of the hopper and near the edge of the shaft. At a distance of about 30 ft. down from the hoist floor, lacing boards, 1 by 12 in., are extended, tapering out to an opening about 6 by 8 ft. They act as a funnel, checking any swing of the can caused by wind and guiding the can up to the hoist. The hoist cable used is ¾-in. 18 by 7 non-spinning type. The expected life of a cable is 50,000 tons.

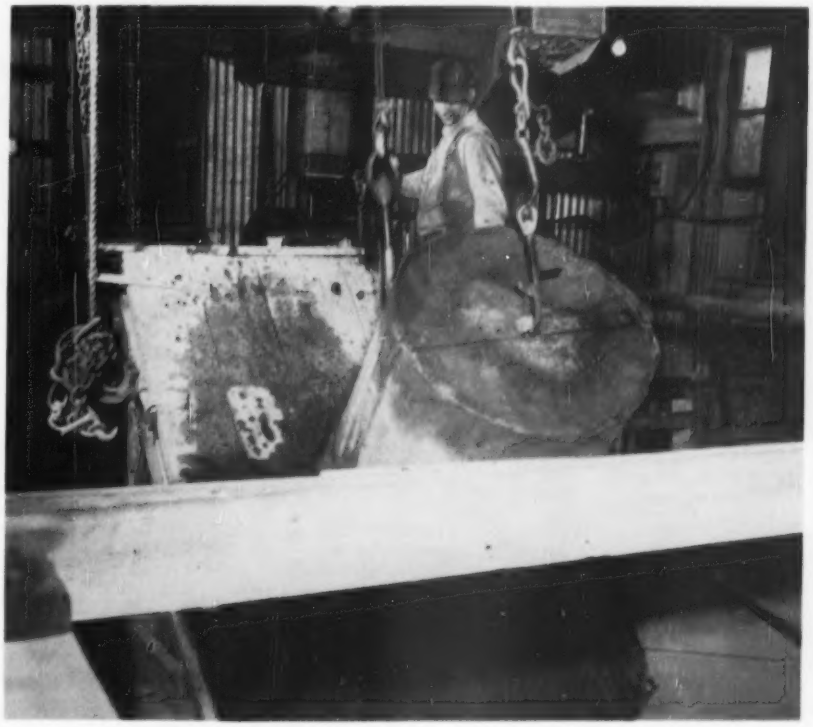
On what is locally referred to as dirt haul, 112-hp. or 125-hp. motors are used. They are kept running continuously. When a can is dumped, the clutch is released. By the time the empty can reaches the bottom, a loaded can is in the center of the shaft ready to be pulled up. The hooker unsnaps the hook from the empty and latches it onto the bail of the loaded can. There are usually 600 or more ¾-ton cans hauled per shift of about 7½ hours.

Perfect synchronization is maintained between the hoistman and the hooker. Near the hoistman's hand is a contact switch, called a "Skiddo" signal, which he flashes so the hooker can move into the clear should the hoistman bump a can or have some spillage when dumping.

The hoistman disengages the clutch about 25 ft. below the dump board and coasts to about eye level. He then brakes it and, at the same time, pulls a hinged trap door that closes the well-hole opening. A tail hook is hooked to a ring in the bottom of the can and the brake is released, allowing the can to up-end and dump into the hopper. The can is righted, the tail hook unhooked, the trap door raised, and the empty is returned. Hoisting speeds range from 1,800 ft. to 2,100 ft. a minute. For handling men, 500 ft. a minute is the requirement.

Until recently, the company used a hooker working with a three-can turntable, electrically controlled. The turntable revolved and centered a can while another was being loaded and a loaded can was ready to rotate into hoisting position. This turntable has been superseded by an ingenious device designed by F. J. Cuddeback. The device consists of a shuttle car holding two cans. It is pushed back and forth

(Continued on page 26)



LOADING A HOPPER: For dumping ore into a hopper, a tail hook is inserted into a ring in the bottom of a can loaded with ore, the brake is released, and the can is up-ended.

THE PANAMA CANAL: This famous waterway extending more than 47 miles across the Isthmus of Panama was formally opened to ship traffic on August 15, 1914. Built under the direction of General George W. Goethals and his staff of construction and sanitary engineers, it is recognized as one of the world's outstanding engineering achievements. Its value to international commerce and development is almost beyond comprehension.

EXPLOSIVES HELP TO REMOVE THREAT TO PANAMA CANAL

Engineering skill and operating know-how plus the application of modern blasting techniques eliminate the danger of a rock slide without interrupting normal movement of traffic through the Canal

N. E. BOUGHTON*

THE "discovery" of a crack in the Panama Canal was widely publicized in the spring of 1954. According to reports, the impending rock slide on Contractor's Hill, in the famous Gaillard Cut where the Panama Canal crosses the Continental Divide, would close the Canal to traffic for a year. The reports were not news to the Panama Canal Company, operator of the Canal. The company had known of the threat of a rock slide since 1938, and in 1954, when the danger seemed imminent, decided to remove part of Contractor's Hill by the skillful use of explosives and modern equipment.

After more than a year's activity involving blasting and excavating more than 3,000,000 cu. yd. of volcanic agglomerate rock and shale, the threat to the Canal has been removed. And, through remarkable feats of engineer-

*Administrative Assistant to the General Manager, Tecon Corporation Dallas, Texas

ing and blasting skill, the Canal remained open during more than a year of construction activity, with ships passing without interruption.

History of Canal

Panama was discovered in 1501, but it was not until 1513, when Balboa sighted the Pacific, that the Isthmus was recognized as a potential route between oceans. In 1521, the Spanish took advantage of the Isthmus by building on the Pacific side a city now known as Old Panama. This city was used as a collection depot for gold from the west coasts of North and South America. Transported by mule back across the Las Cruces trail, the gold was sent to Europe by ship from the city of Colon. In 1671, the pirate Morgan used this same trail to attack Old Panama from the rear, completely sacking it. The ruins of Old Panama, including what must have been one of the first four-story buildings in the New World, may still be seen.

Panama City was rebuilt and the Las Cruces trail continued in its role as the short cut between oceans. But business was slow until the '49 Gold Rush and the subsequent opening of the West brought hordes of people across the Isthmus. Business became so good that it inspired the construction of a railroad, which was completed in 1855 and is still in use. In 1880, the French Canal Company was organized and construction was started on the Panama Canal, but disease and inability to finance such a large project spelled defeat. Recently, several relics of the French effort were found. The apparent ratio of Cognac bottles to picks and other tools might indicate one handicap of the first excavators at Contractor's Hill.

The United States Government bought the rights to the Panama Canal in 1904 and began construction, taking up where the French had left off. The project was completed in ten years at a total cost of $380,000,000 and the Canal was opened to traffic. Shortly after the opening, the Canal was closed by a very large slide that blocked it for nearly a year, but it was finally

CULEBRA (GAILLARD) CUT: This view of the Culebra Cut, now known as the Gaillard Cut, was photographed on May 17, 1913, looking north from Contractor's Hill. To complete construction to specifications – 8 mi. long, 300 ft. deep, and a bottom width of 1,000 ft. – more than 152,000,000 cu. yd. of rock and conglomerate were blasted and excavated.

CONTRACTOR'S HILL: This is the section of Contractor's Hill in which the crack was discovered, as photographed from Purple Rock directly across the Canal from the trouble area. The hill rises 332 ft. above the Canal's water level.

EXCAVATION IN PROGRESS: After careful planning by Tecon's engineers, the cracked area in Contractor's Hill, 1,000 ft. long and 600 ft. deep, was excavated in a series of steps, or benches, 40 ft. deep and 20 to 40 ft. wide.

reopened to traffic in 1916. Since that time the Panama Canal Company has removed between 20 and 30 million cu. yd. of earth and shale, which had gradually worked their way into the Canal. A contract with Tecon Corporation of Dallas, Texas, recently completed, was the first large excavation job that has been let to a private contractor for the Canal as it is now used.

Site of the Trouble

Contractor's Hill is shaped much like a potato with one flat side, the flat side being the cliff overhanging the Canal. On top were two crests, one going to elevation 417 and one to elevation 385; water level of the Canal is at elevation 85. It is a huge block of highly fractured volcanic agglomerate rock resting on a sloped bed of Cucaracha shale. The hill is crisscrossed and cubed by vertical joints running 15 degrees and 75 degrees off the line of the Canal and bedding planes dipping about 30 degrees to 50 degrees toward the Canal.

Contractor's Hill, which rises 332 ft. above the water level of the Canal, and its twin, Gold Hill, on the other side had always been considered relatively stable. However, in 1938 survey parties discovered a crack running roughly parallel to the Canal, nearly 1,000 ft. long and removed from the center of the Canal by about 100 ft. Soundings determined it to be up to 600 ft. in depth, and measurement over the years indicated that the crack was widening. The movement was in and out, but the inward movement never quite equaled the outward movement. The threat to the Canal was not so much that the free wedge of rock, bounded on one side by the vertical cliff rising from the Canal and on the other by the crack, would topple over, but that it would slide bottom first into the Canal.

The engineers of the Panama Canal Company were of the opinion that the crack was caused by a movement of the Cucaracha shale formation underlying Contractor's Hill and was aggravated by hydrostatic pressure against the free wedge. To prevent a slide, it was decided to drive a tunnel perpendicular to the face of the hill to intersect the crack and relieve the hydrostatic pressure and to remove the

free wedge of rock and a small portion behind the crack.

After bids from several companies had been received and reviewed, discussions were held with the low bidder, Tecon Corporation of Dallas, Texas, concerning its experience, capabilities, financial responsibility, and proposed method of performing the contract. The contract specifications provided for a lump sum payment for mobilization of equipment in Panama and for two unit prices, one for rock excavation and one for shale excavation. In the event of a slide, the contractor was not to be held liable unless it could be proved that he had been negligent; however, he risked his equipment and reputation on his ability to complete the project.

Equipment

When the contract was awarded, basic thinking, developed during the preparation of the estimate, was reexamined and equipment needs were thoroughly planned. The equipment application was worked out from the time allowed for completion of the job, weighing such factors as ocean hauling, flexibility, lifting facilities available at Panama, and economics. A 2½-cu. yd. shovel was selected as the basic unit; three Bucyrus-Erie 54B's were chosen and three spreads of equipment built around their production rates. Each spread consisted of a Mayhew Hurricane rotary well drill, a shovel, and five 22-ton Euclid end-dump haul units.

Auxiliary equipment consisted of four Allis-Chalmers HD-20 tractors with dozer blades, two Caterpillar D8 tractors with 600-c.f.m. Gardner-Denver compressors mounted on the rear and two Gardner-Denver wagon drills mounted on the front, one Caterpillar Model 12 motor grader, one wagon drill, one 600-c.f.m. compressor, a grease truck, and transportation equipment. Most of these units, which cost about $900,000, were purchased new, and factories were urged to expedite delivery because of the national significance of the project. Delivery was made in New Orleans and two leased freighters transported the equipment to Panama.

Along with the equipment went spare parts, shop tools, office equipment, and personal effects of the crew that was sent from the United States. The equipment and personnel began arriving in July, and excavation was started immediately. The 5 by 7-ft. tunnel project was subcontracted to Bildon, Inc., a Panama firm. The driving of the tunnel was completed quickly by using heavy charges of explosives, which threw the blasted material out of the tunnel entrance and across the Canal. Each blast gave the appearance of a giant, open-choke shotgun firing charges of rock at Gold Hill on the opposite side.

Planning

Careful planning by the Canal company indicated that one-half of the free wedge of rock and enough rock

REMOVING THE FLYWALL: After serving its purpose of protecting the Canal from blasting inside the pit area, the flywall was removed by drilling three rows of short holes and charging them with a low dynamite-loading factor.

behind the fissure should be removed to provide access to the work area and to stabilize the remaining slope. This was accomplished by cutting the hill down to elevation 390 on one end and to 370 on the other end, and by working the remainder down in steps, or benches, 40 ft. deep and varying from 20 to 40 ft. in width. At elevation 150 a wide berm was cut out to the original face of the cliff.

Access to the work area was made on each end of the hill and through the middle at the higher elevation. Each bench was excavated from the finish line out to the face of the hill before the next one was started. A flywall was left to control the blasted material. In general, the working face of the excavation was perpendicular to the crack, and sequence blasting patterns were laid out as follows. On the Canal side of the crack the distance from the crack to the adjacent line of holes was less than the distance from that line to the next. On the other side it was greater. The sequence of firing the blast was from the corner of the block nearest the face and farthest from the Canal, progressing into the block and toward the Canal. This sequence was controlled by regular and short-period delay electric blasting caps. Results showed excellent fragmentation of the material, which was evenly stacked close to the original face.

Drilling and Blasting

The highly fractured nature of the volcanic rock formation, with an occasional intrusion of basalt, required that blast holes vary in size and depth and that different types of dynamite be used. Holes ranged from 2 to 45 ft. in depth and from 1¾ to 5¾ in. in diameter. Forty per cent extra, semi-gelatin, and straight gelatin dynamites were used in a variety of diameters.

Of special interest was the system used for removing the flywall after it had served its purpose of protecting the Canal from blasting inside the pit area. To break the rock in this wall to a size that could be handled by power shovels, without any of it falling over the edge, required the development of a new blasting technique. This called for drilling one row of holes into the wall at a slightly downward angle through half its width, with second and third rows drilled above the first row, either horizontally or inclined slightly upward. Sequence blasting was used to break up the wall and to lift it inward. A low dynamite-loading

FRACTURED ROCK: The highly fractured rock formations required wide variations both in the size and depth of blast holes and in the grades and sizes of dynamite used. Sequence blasting helped in solving unusual rock-removal problems.

OVERHANGING BOULDERS: To prevent boulders on the edge of the hill from falling into the Canal, snake lines attached to bulldozers were used to drag the big rock back onto the benches before removing them with power shovels.

factor was used to avoid throwing rock into the Canal. The necessity of using a low dynamite-loading factor resulted in poorly fractured rock and complicated the removal problem. Frequently, the shovels had to place their dippers on the Canal side of the broken material and rake the rock inward before it was scooped up and loaded into trucks. As a consequence, there was more than usual wear on dipper gates and latches. In some cases, snake lines were used to drag the boulders in before they were loaded onto hauling units.

The blasting techniques outlined were very succesful – less than 1 per cent of the rock excavated fell into the Canal. The most difficult blasting problem encountered was in an area where the cliff actually overhung the Canal. In that situation, shaped charges were placed on the Canal side and careful calculation of the delay periods of the electric blasting caps resulted in the shaped charges' giving a slight additional boost to the flywall when it was fired in the usual manner. No rock from this method of blasting went into the Canal. In spite of careful planning and extreme care in carrying out the blasting details, several blocks of material in the overhanging slope separated along old cleavage planes and fell into the Canal. The largest of these, about 5,000 cu. yd., fell during the night, completely unobserved. There was no interruption to Canal traffic or any damage to equipment or accidents to personnel, resulting from slides. However, this possibility was always a disturbing element.

Disposal of Blasted Material

In planning disposal of blasted material, two considerations dictated a short haul. Obviously, the economy of a short haul was desirable, but of prime importance was keeping Contractor's Hill close to its original weight to pre-

vent an upthrust of the underlying shale bed and consequent settlement of Gold Hill on the opposite side of the Canal. For these reasons, the excavated material was loaded on the back side of the hill. As it became difficult to find space for further dumping, the spoil area was pushed outward to fill in an old reservoir.

One dozer was sufficient to keep the fill area level and one Caterpillar Model 12 motor grader maintained the haul road in good condition. This convenient method of waste-material disposal was significant when compared with the methods used on the original construction of the Canal. In those early days, it was necessary to build a trestle across a valley, bringing trainloads of spoil onto it and dumping them by pulling a plow the length of the trains. When the elevation of the fill reached that of the track, the track had to be relocated. Already there are signs of the jungle returning to Contractor's Hill; for example, a surveyor's stake driven into an 80-ft. fill of rock and shale has taken root and sprouted leaves.

Completion of the Contractor's Hill project in October of 1955 marked the end of a rock-excavation project in which approximately 2,460,000 cu. yd. of volcanic agglomerate rock and 670,250 cu. yd. of shale were removed and disposed of in 15 months' time. The job required about 110 miles of blast-hole drilling and the firing of 700 blasts of dynamite, ranging in size from a few pounds for trimming shots to one charge of 6,000 lb.

Personnel

The Panama Canal Company's personnel on the project included Colonel Hugh M. Arnold, engineering and construction director; Leo W. Cagley, chief of the Civil Engineering Branch; Colonel Edward B. Jennings and Charles Brandal, project engineer. Tecon Corporation was represented by A. Ray Smith, general manager; W. C. Wheeler, assistant general manager; R. L. Hallbeck, chief engineer; J. L. Phillips, project manager; and John H. Wiley, project engineer. The consultants were Dr. Arthur Casagrande, Dr. Clifton W. Livingston, Hibbert Hill, and Edward Abbott.

The subcontractors for the tunnel section, Bildon, Inc., of Panama, materially aided in the success of the project. The construction crew of Tecon Corporation was composed of skilled labor and supervisory personnel from the United States, some United States citizens living in Panama, and local Panamanian citizens.

The maintenance of uninterrupted traffic through the Canal and the record of no accidents to personnel or damage to equipment while work was in progress pay high tribute to everyone associated with the job, particularly to the engineers who planned and executed this difficult rock-removal project in Panama.

IN THE PIT AREA: In general, the working faces for drilling, blasting, and excavating were perpendicular to the crack. Results from sequence blasting, using 40 per cent dynamite primed with regular and short-period delay electric blasting caps, were consistently satisfactory.

Pickands Mather

MINERS RECEIVE TOP SAFETY AWARDS

Employes of Mahoning and Zenith mines in Minnesota honored by company officials for outstanding achievements in accident prevention

August 26 and 28 were memorable days in the communities of Hibbing and Ely, Minnesota. On those dates, Pickands Mather & Co. officials were hosts at ceremonies that highlighted the formal presentations of Sentinels of Safety trophy awards to the company's Mahoning and Zenith mines. These mines were the winners in the 1954 National Safety Competition in the open-pit and underground metal mines groups, respectively. Mahoning mine was operated 527,355 man-hours in 1954 without a lost-time injury, and Zenith mine had a perfect record during 501,160 man-hours of work in the same period.

On the 26th, approximately 400 employes and their families gathered between shifts at Hibbing for the presentation of awards to Mahoning mine. W. D. Webb, superintendent of the mine, was master of ceremonies for the affair, which was held in a large building on the mine grounds. Following completion of the ceremonies a buffet lunch was served to everyone present.

The ceremony honoring the Zenith mine employes was held in the evening of the 28th, in the Community Center building in Ely. Dinner was served to about 250 employes and guests prior to the ceremony, which was broadcast by radio station WELY.

Representatives of the management personnel of Pickands Mather & Co. from its offices in Duluth and Cleveland attended both ceremonies and addressed the miners. At the Mahoning mine gathering, E. L. Joppa, PM's general manager of mines, remarked that he was impressed by the presence of the miners' wives. He said this was a new and pleasant innovation, one he felt sure would help in maintaining strict observance of company regulations and a more widespread appreciation of the value of safe working conditions.

M. L. Bradt, general superintendent of the Central District, commented on the fact that safety in any job, particularly in mine work, does not come about automatically. "It takes the combined efforts of all concerned to avoid accidents," he said. "Everyone

COOPERATION GUARANTEED: After congratulating the Mahoning and Zenith miners for outstanding injury-free records, W. F. Eckert, director of safety of Pickands Mather & Co., assured all employes that everything humanly possible will be done by PM management to maintain safety in the operations of its mines and mills.

THE TROPHY: Felix E. Wormser, assistant secretary of the Department of the Interior, left, presents the bronze Sentinels of Safety trophy to Veikko Hirvela, chairman of Mahoning mine's Employe Safety Committee, representing his associates.

has to think safety, and put his shoulder to the wheel and practice safety."

William F. Eckert, safety director of all PM's operations, pointed out that men in management positions have moral obligations to introduce and maintain safe working conditions in a mine or mill. "They know from past experience," he said, "that mines with high accident rates also have high operating costs."

Felix E. Wormser Presents Sentinels of Safety Trophies

At each ceremony, the Sentinels of Safety trophy was presented by Felix E. Wormser, assistant secretary of the Department of the Interior. In making the presentations, he paid high tribute to the employes of Mahoning and Zenith mines for their notable achievements in working safely during more than half a million man-hours of exposure at each operation.

W. D. Webb, superintendent of the Mahoning mine, Veikko Hirvela, chairman, Employes Safety Committee, and Louis Terzich, chairman, Foremen's Safety Committee, accepted the Sentinels of Safety trophy at Hibbing. B. S. Richards, superintendent of the Zenith mine, accepted the trophy at the Ely ceremony.

In his remarks, Mr. Wormser said, "For 30 years the National Safety Competition, conducted by the Bureau of Mines, has proved its effectiveness as an outstanding implement for promoting safety among the Nation's mineral industries. Inaugurated in 1925, in cooperation with THE EXPLOSIVES ENGINEER, this annual competition has produced remarkable achievements in safety year after year.

"If all of the Nation's mines and quarries had done as well in accident prevention as those which participated in the 1954 National Safety Competition, many lives would have been saved and numerous injuries prevented."

The significance of the bronze Sentinels of Safety trophy presented to the winners of the National Safety Competition was explained at both ceremonies by Thomas E. Miller, representing THE EXPLOSIVES ENGINEER, which annually awards the trophies to the winners in this nationwide contest. "Let's take a look at this trophy which has just been presented to you," he said. "It represents a mother holding her baby in her arms, and the baby is reaching out to welcome the father on his safe return from a shift in the mine. I wish you would keep that picture before you always, on the job and off. Think of your wife and children, your mother, sisters, brothers, waiting at home for your safe return at the end of your shift. That is what we are all working for. There really isn't much reason to work at all unless you are going to come home safe and sound every night to the people who love you. If you will do that, if you will keep that picture in your mind, you will never take a chance with injury or death as you work out there in the mine with iron and steel and dynamite."

The Mahoning Ceremony

To the Mahoning miners, Mr. Wormser commented that the U. S. Bureau of Mines records show that in the 25 years in which this mine has entered the competition, it has received honorable mention six times, and won the Sentinels of Safety trophy award nine times.

"During the 25 years of participation in this contest," he said, "Mahoning mine was operated for approximately 11 million man-hours with only 16 lost-time injuries, indicating a frequency rate of 1.38 injuries per million man-hours, the best overall record in the 30-year history of this competition. Such records are made by constant adherence to time-tested safety laws and to practices fortified by a well-founded and well-maintained safety program."

In commenting on the Mahoning miners' winning the top award among open-pit mines nine times, Mr. Miller said, "Your amazing safety record in this mine, your remarkable ability to work millions of man-hours without

THE FLAG: Anton Sikonja, president of the Zenith Local, United Steelworkers of America, left, accepts the award of the Sentinels of Safety flag for the Zenith miners from Thomas E. Miller, representing The Explosives Engineer.

accident or injury, is an achievement that has not been equaled by any open-pit mine anywhere in the world so far as the records show. If we could compare open-pit mines with underground mines and quarries, I am sure the record of you men at Mahoning would stand up against the best of them."

FOR ALL TO SEE: At the end of the ceremony at Mahoning mine, the Sentinels of Safety flag was raised to the top of the pole, under the Stars and Stripes, by Explorer Scouts Tom Lang and Tom Znidar.

Tributes to Zenith Miners

In addressing the Zenith miners, Mr. Wormser commented that in the 25 years this mine has been entered in the competition, the overall frequency rate of 13.3 injuries is considerably below the average rate for all mines enrolled in this group.

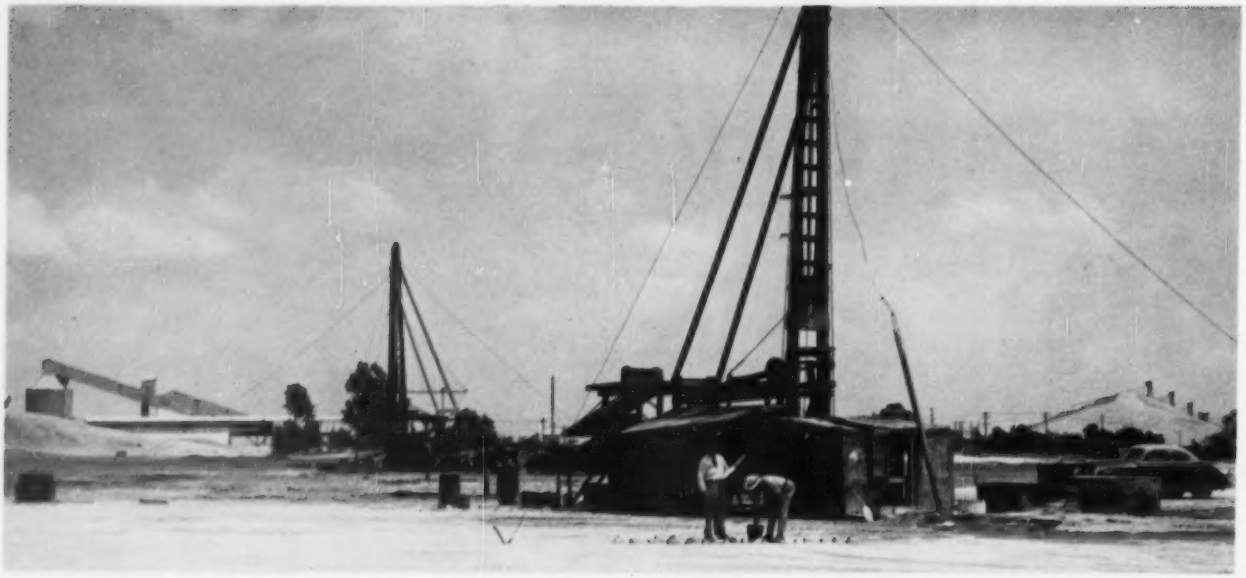
"You have to be good to win this competition these days," Mr. Miller told the Zenith mine employes. "There were 66 metal mines enrolled in the 1954 competition and of these, eight worked through the whole year without a lost-time accident. But your half-a-million man-hours of work without a lost-time accident was the best record of them all. A safety record like that, which tops all the metal mines in the country, is something to be proud of, something to stick out your chests about."

Mr. Miller presented the Sentinels of Safety flag to John Znidar, past chairman, Employes Safety Committee of the Mahoning mine, and to Anton Sikonja, president, Zenith Local, United Steelworkers of America, representing the Zenith mine.

Individual Certificates of Achievement in Safety, provided by the Bureau of Mines, were presented by John A. Johnson, district engineer for the Bureau, to the Mahoning and Zenith employes.

Samuel A. Gustavson, chief of the Minneapolis Field Office, U. S. Bureau of Mines, presented the Joseph A. Holmes Certificate of Honor to both mines. The Award of Honor of the National Safety Council was presented to the Zenith mine by Gil Grieve, staff representative of the council.

Other speakers at the ceremonies were A. E. Anundsen, supervisor of safety and industrial relations for Pickands Mather & Co.; George Teller and Sam Swanson, representatives of the United Steelworkers of America; Ben Kangas, mine inspector for Minnesota's St. Louis County; W. V. Langen, principal of Ely High School, toastmaster at the Zenith dinner; Dr. J. P. Grahek, mayor of Ely; Frank Wilson, vocal instructor at Ely High School; Charles Miron, mining captain, and chairman of Zenith's Foremen's Safety Committee; and Matt Banovetz, chairman of the Employes Safety Committee at the Zenith mine.



PROSPECTING FOR ORE: When prospecting in mineralized areas, cuttings from churn drills are panned and examined by Eagle-Picher geologists. When samples show a commercial grade, drillers limit progress to runs of 2½ ft.

Eagle-Picher Company

(Continued from page 15)

from the hopper chute by an air cylinder. When the empty comes down, the hooker swings it behind the load which is centered. When the loaded can leaves, the cylinder pulls the shuttle car and empty under the chute where a bump block slides the empty to the front of the car for loading. This centers it for hoisting when the car is pushed forward.

Diversified Interests

Under the direction of T. Spencer Shore, president of The Eagle-Picher Company, expansion and diversification of company interests are being accomplished. Besides its mining activities in the Tri-State District, in the states of Arizona and Nevada, in the Illinois-Wisconsin area, and in Mexico, the company owns and operates an Insulating Division with plants in Joplin, Missouri, and in Wabash, Indiana. Its plant at Dover, New Jersey, makes aluminum doors, windows, and combination storm windows and screens. A plant at Reno, Nevada, manufactures Floor-Dry and all Celatom products.

The Pigment Division manufactures litharge, red lead, silicates of white lead, zinc oxide, cadmium, and sulphuric acid at plants in Newark, New Jersey; Joplin, Missouri; Hillsboro, Illinois; and Galena, Kansas. Waxed paper, molded fiber glass, and fiberboard products for the automotive trade are produced at plants located in River Rouge, Michigan; Los Angeles, California; and Philadelphia, Pennsylvania.

Molded, extruded, and mechanical rubber goods of all types are manufactured by the Ohio Rubber Division at plants located in Willoughby, Ohio; Long Beach, California; and Conneautville, Pennsylvania. In Seattle, Washington, the company operates on a fifty-fifty basis with the Associated Lead and Zinc Company in the manufacture of lead oxides, red lead, and litharge at that location.

A large and well-staffed research laboratory is maintained in Joplin, Missouri, where work is carried on constantly on improvements and new applications of the company's products.

In the preparation of this article, the author wishes to express grateful appreciation for the cooperation of his associates in the Mining and Smelting Division of The Eagle-Picher Company in the Tri-State District.

VIBRATION TROUBLES?

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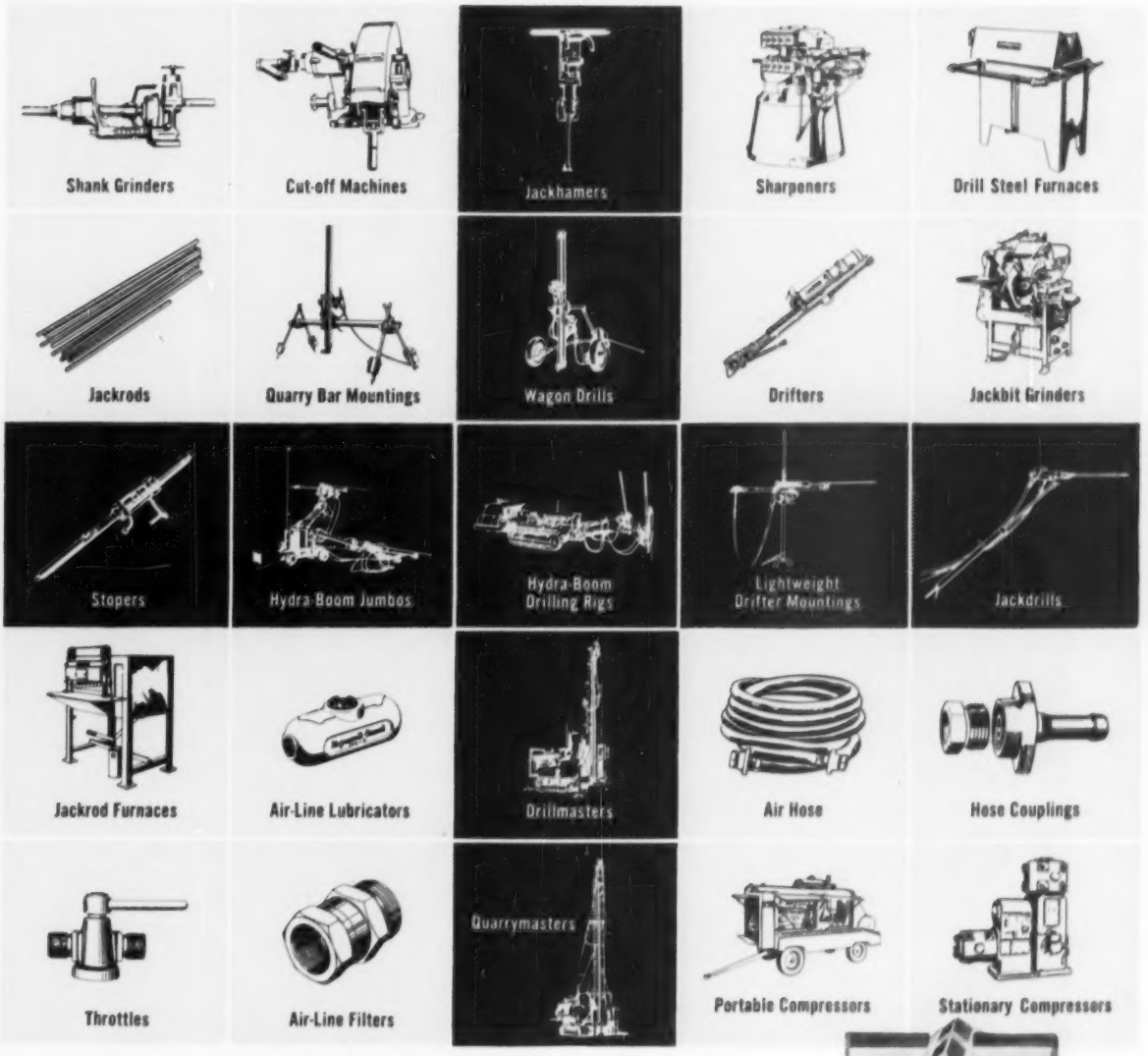

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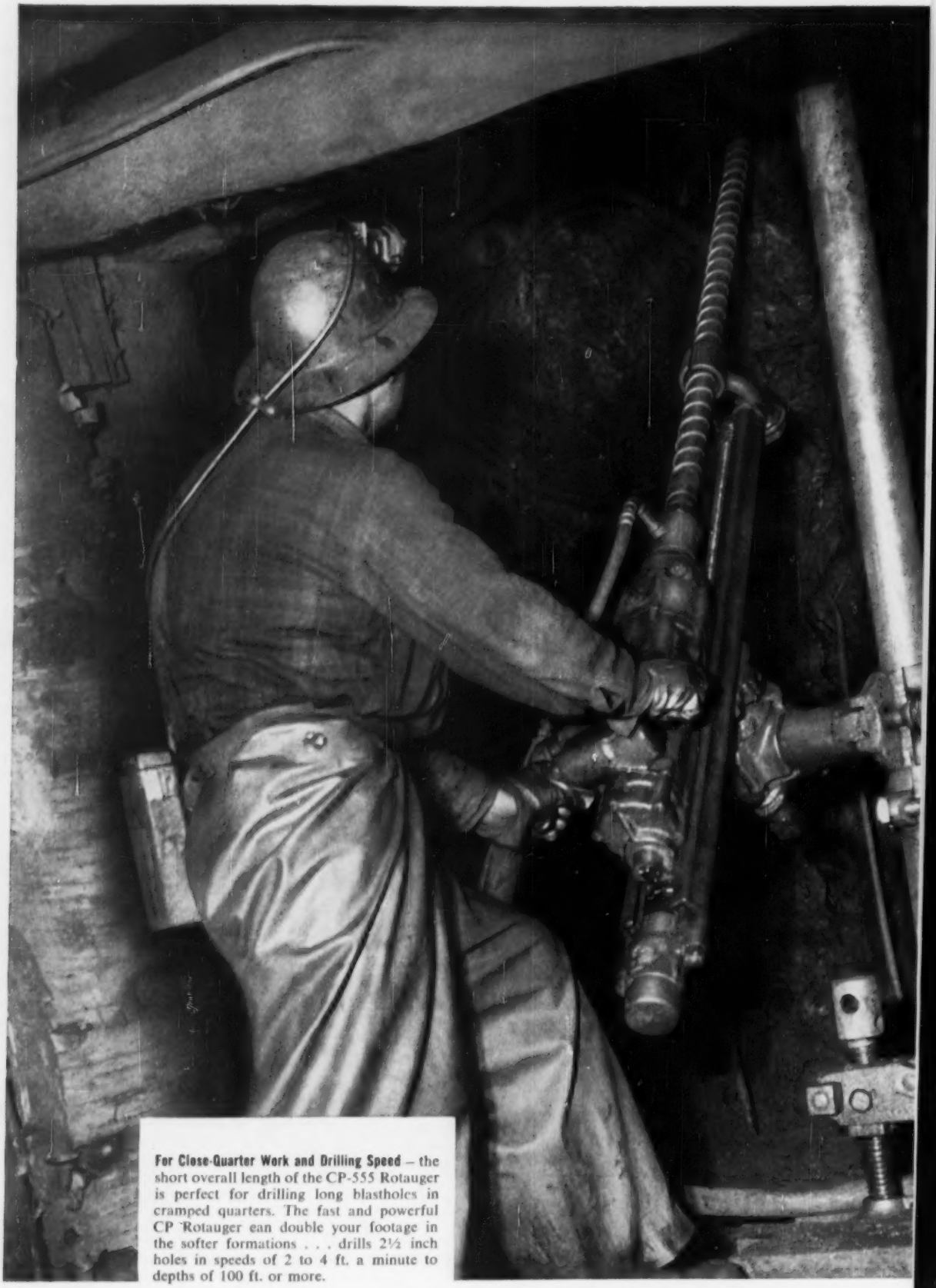

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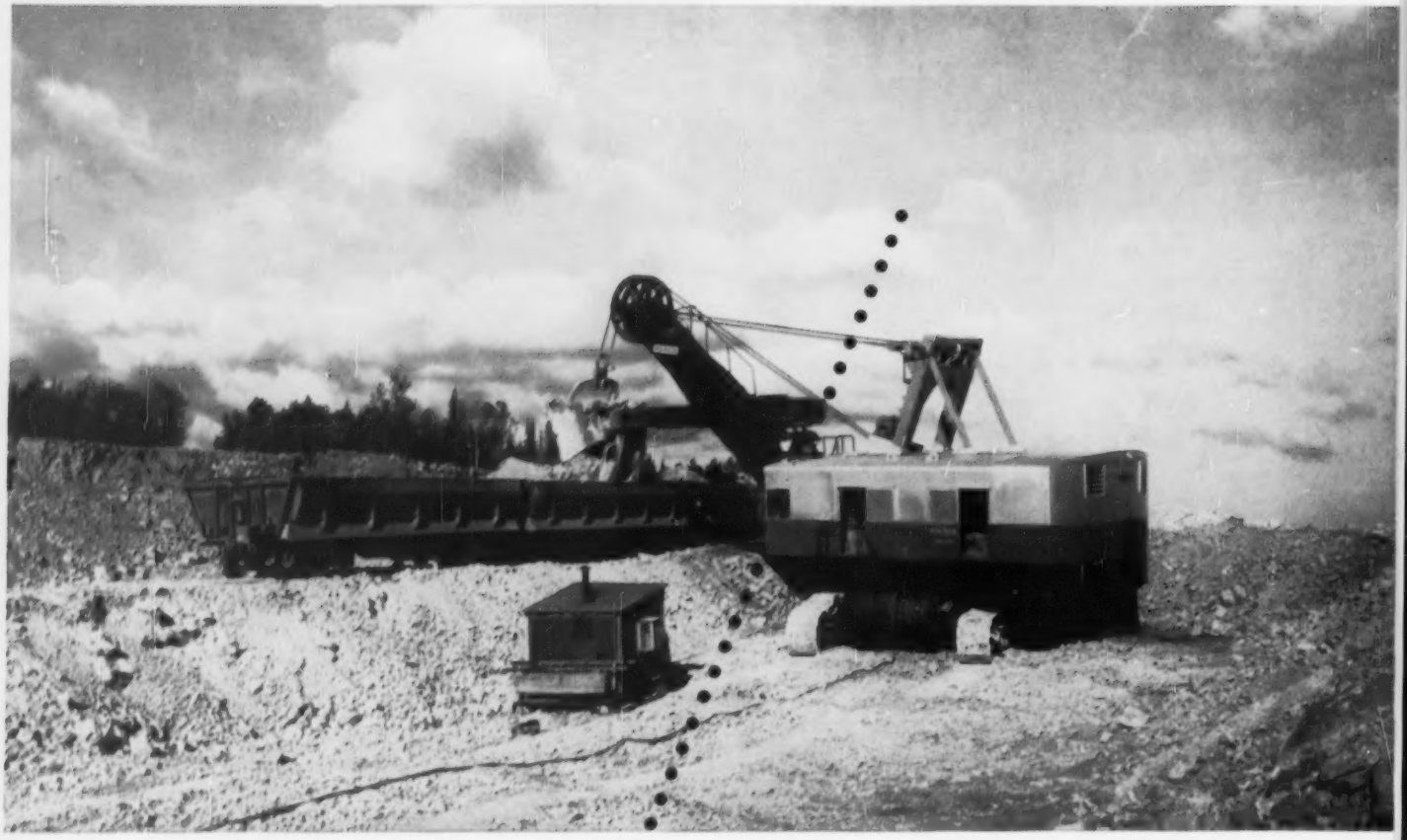

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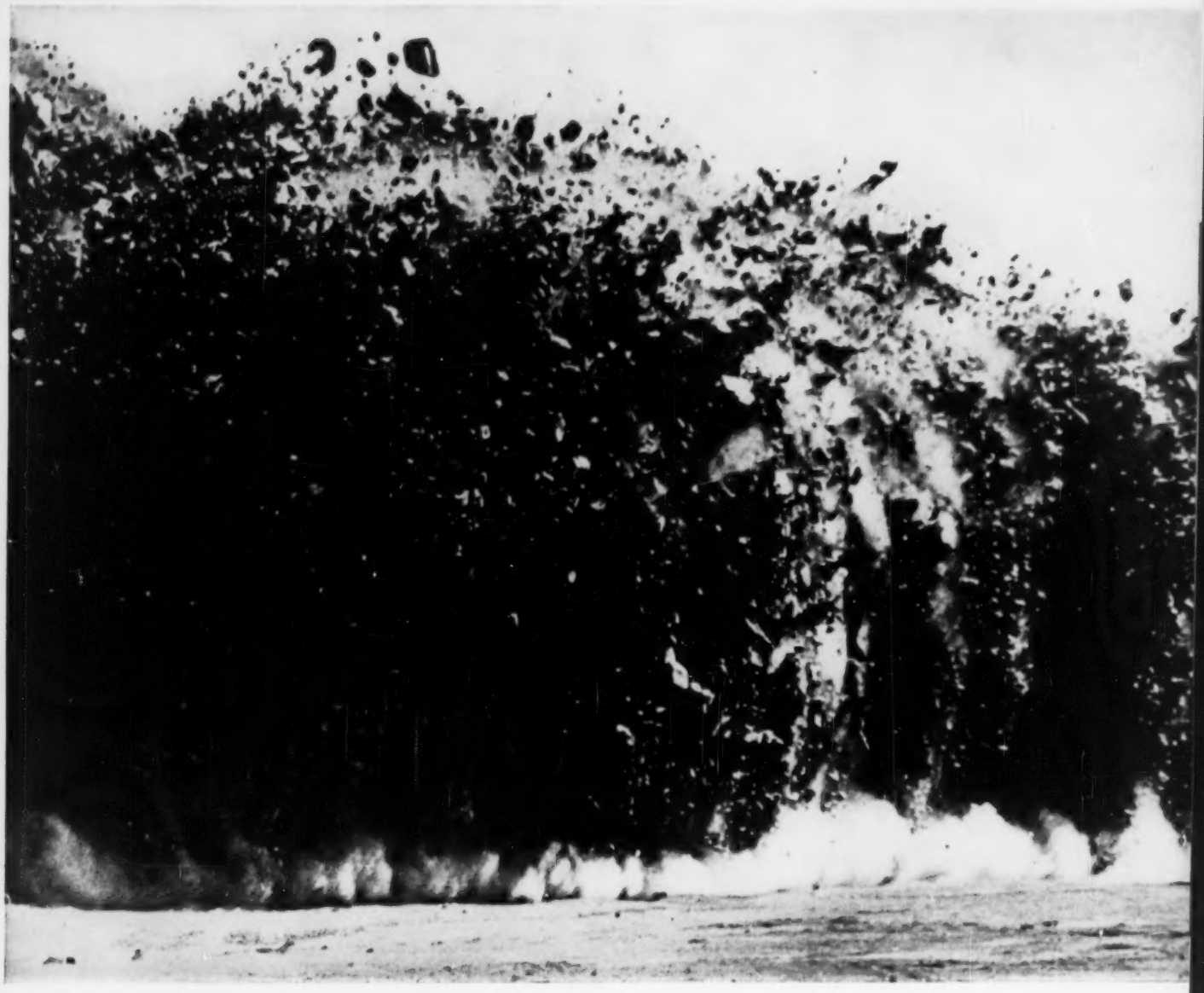

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